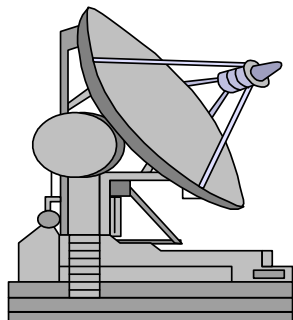




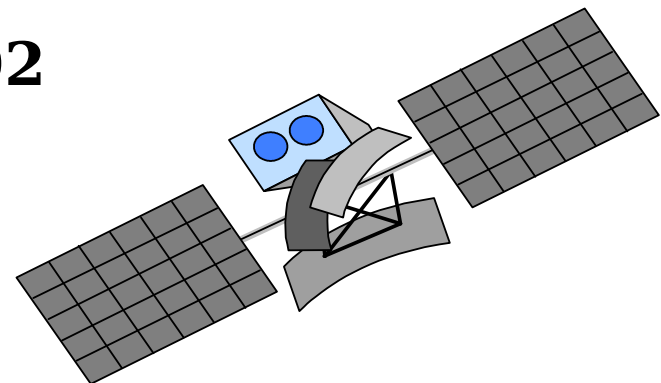
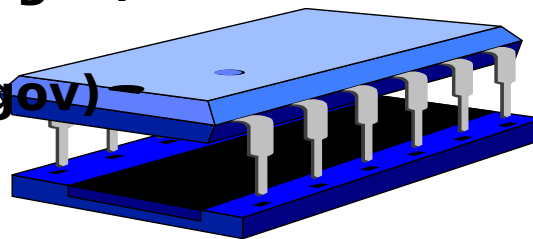
Wireless Telemetry for Industrial Applications

DARPA PI Meeting

Santa Fe - January 2002



Wayne W. Manges
(mangesww@ornl.gov)
Glenn O. Allgood
(allgoodgo@ornl.gov)



[Http://orcmt.oakridge.org/wireless](http://orcmt.oakridge.org/wireless)

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY



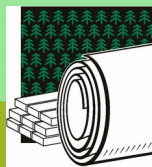
ORNL's Wireless Program Focuses on Industrial Applications For Government Benefit

- **Dept. of Energy - Office of Industrial Technology, Sensors and Controls**
- **CRADA partners - oil, Graviton, others**
- **DOD - Navy and Navy contractor, others**
- **Path Forward - smaller, faster, cheaper**

Industries of the Future Strategy

*Technology
for Today*

**Support
RD&D
for 9
energy-
intensive
industry-
specific
technologies**
• **Enabling
(cross-
cutting)
technologies**



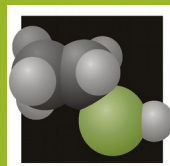
Forest
Products



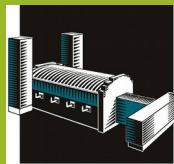
Agriculture



Aluminum



Chemicals



Glass



Metalcasting



Mining



Petroleum
Refining



Steel

***Technology
for the
Future***

Deliver Available Tools

Sensors & Control Program Objective

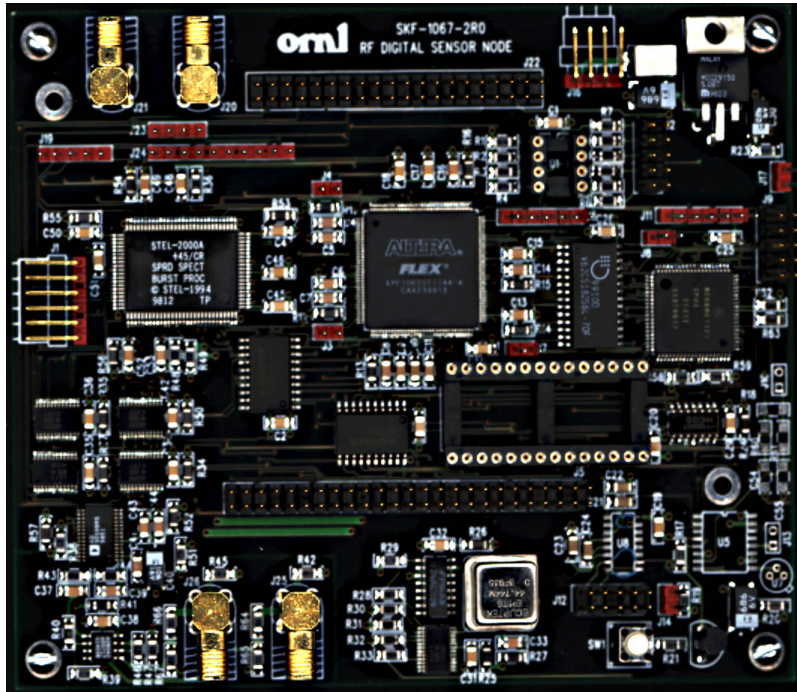
■ **Provide high-priority crosscutting technology solutions identified in IOF roadmaps, specifically in the areas of**

- **Advanced sensor technologies**
 - » **Chemical/physical measurements in demanding applications (harsh environments, high-speed, industrial robustness, miniaturization)**
- **Improved information processing**
 - » **Signal processing, imaging and displays, neural networks, modeling and simulation**
- **Intelligent control systems**
 - » **Smart control, sensor fusion, automation**

We Accomplished What We Set Out To Do

- **Year 1 - Functional Description and Requirements - some surprises, several external requests**
- **Year 2 - Architecture Specification, components - more external requests**
- **Year 3 - Integrated systems and Demo - external requests and potential partners**

Our Third Year Demo Showed Feasibility



- **Standards - IEEE 1451, Ethernet, 4-20ma**
- **Communication - Direct Sequence, Spread Spectrum, CDMA RF**
- **Robust - 140 feet in Bowater paper mill**

Challenges in Wireless Technology Identified by National Research Council

- **Eliminating Interference - reliable communications**
- **Developing Intelligent Wireless Sensors - reduced deployment cost**
- **Developing Robust Architectures - for harsh environments**
- **Developing Remote Power - long lasting and reliable**
- **Developing Standardized Protocols - plug-and-play (without the plug)**

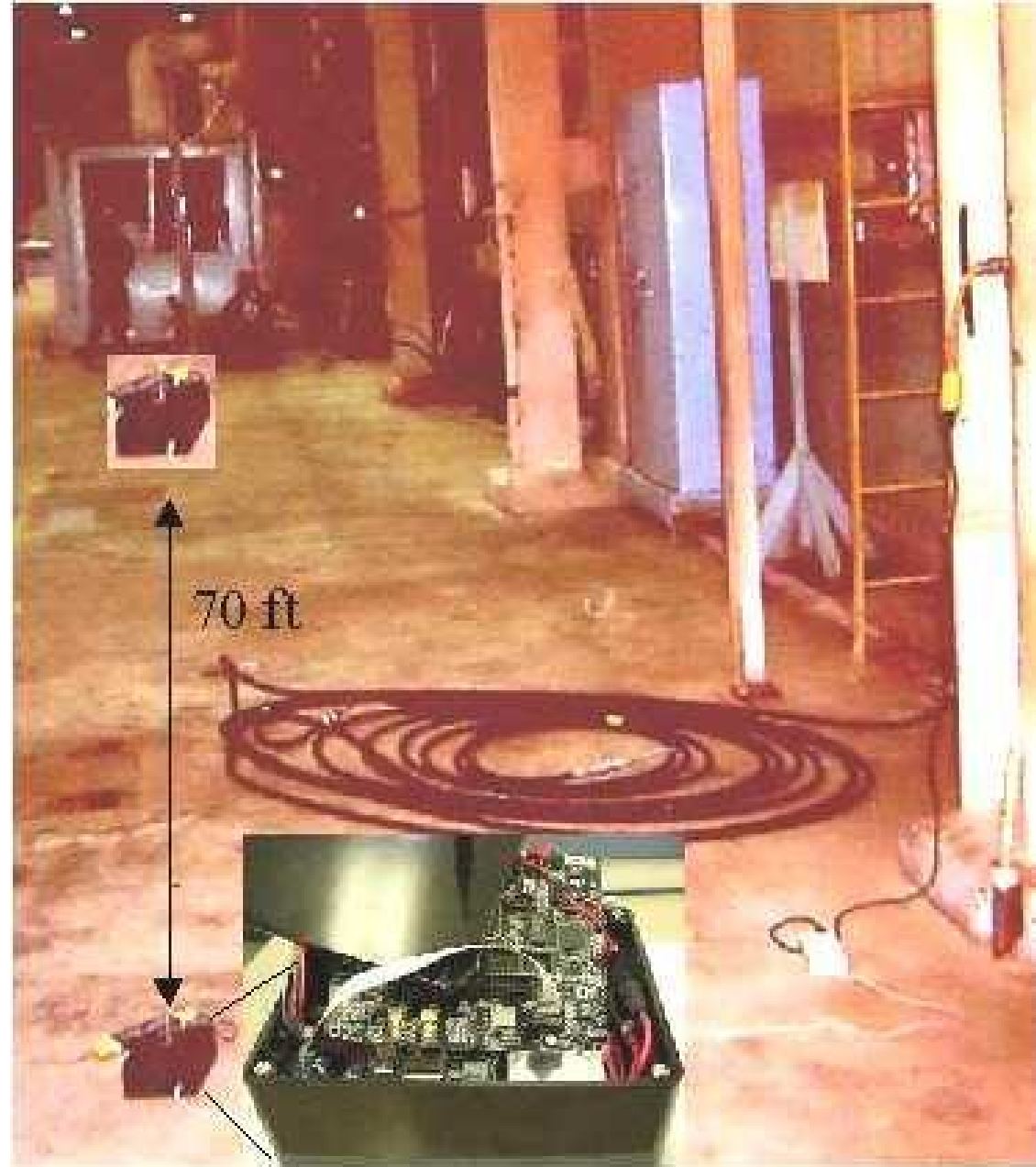
Key Requirements Identified

- **Operate Unattended - Reduced cost of deployment and maintenance**
 - self-configuring,
 - self starting,
 - self healing
- **Support Legacy Systems - Sensors and networks, open standards (1451)**
- **Operate in Industrial Environment - temperature, dust, vibration**

Demonstration in Bowater Plant Proved Performance

- **Robust - up to 140 feet in harsh environment**
- **Standards - 4-20ma standard pressure and temperature sensors, IEEE 1451 data structures, ethernet**
- **Throughput - updates suitable for real-time displays**
- **Low Power - 1/10000 power density of narrow band systems**

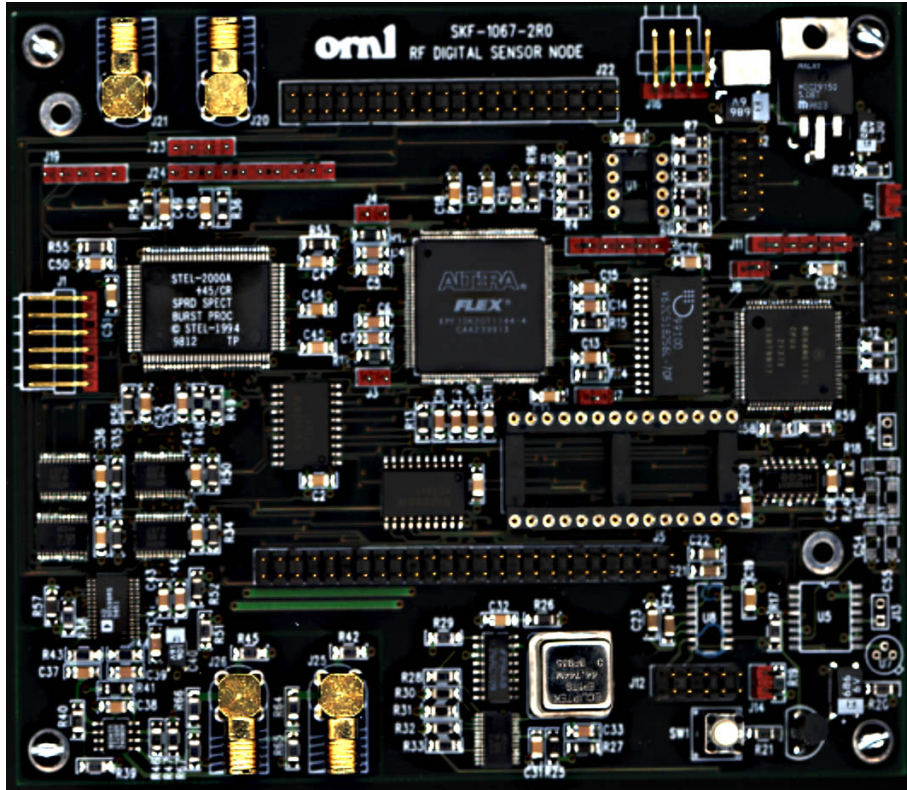
- **Standards -
IEEE 1451,
Ethernet, 4-
20ma**
- **Communication
- Direct
Sequence,
Spread
Spectrum,
CDMA RF**
- **Robust - 140
feet in Bowater
paper mill**



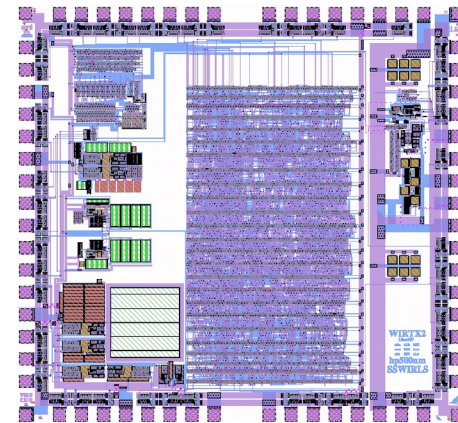
Our Path is Clear

Ground breaking work in

- Wireless protocols
- Mixed Signal ASICs
- Low Power Designs

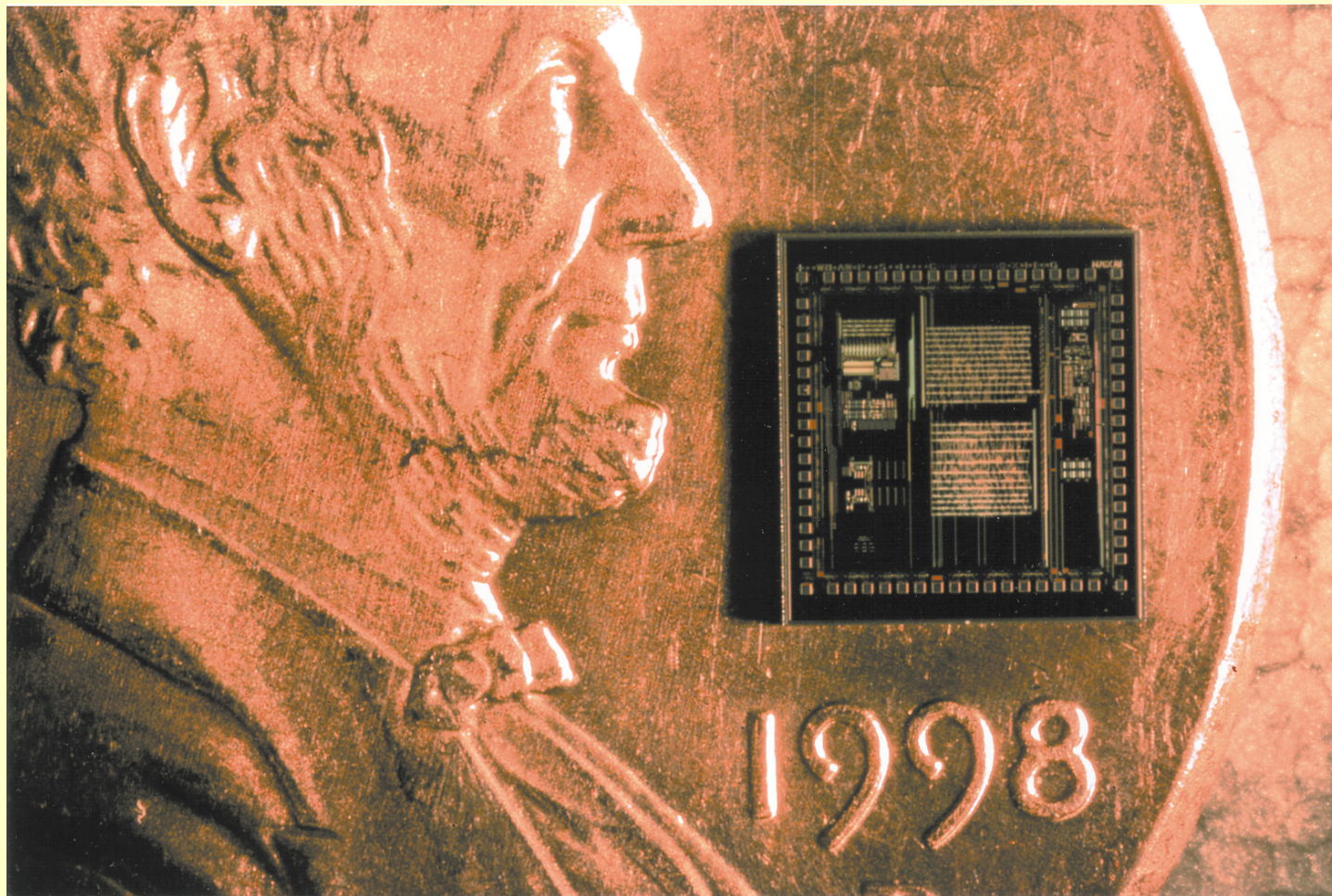


← 10 cm (4 inches) →



← 3.3 mm (1/8 inch) →

MULTI-CHANNEL INTEGRATED SPREAD-SPECTRUM TELESENSOR



OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY



SiGe Work Begun on This Project

- **AMS SiGe process has f_T up to 30 GHz, adequate for 5.8 GHz systems**
- **Two SiGe chips have been designed and submitted for fabrication**
 - **Individual devices for characterization and model verification**
 - **Several RF functional blocks needed for a 5.8 GHz bi-directional system**

Critical Next Steps Awaiting Funding and Partnerships

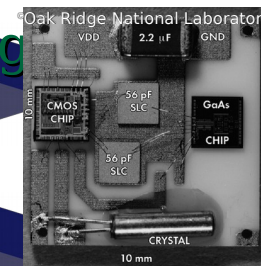
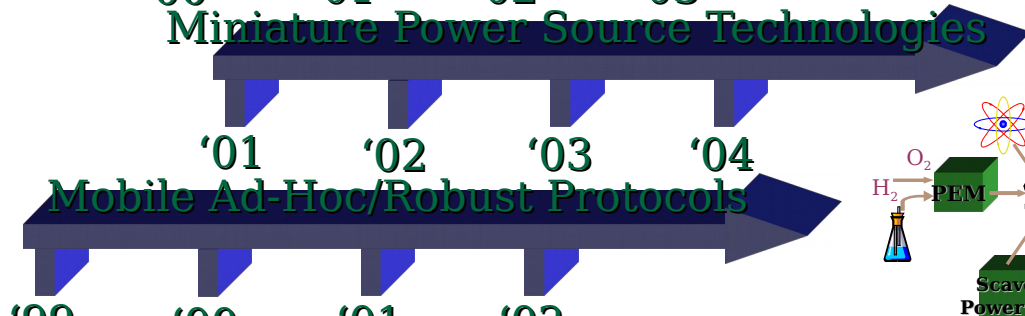
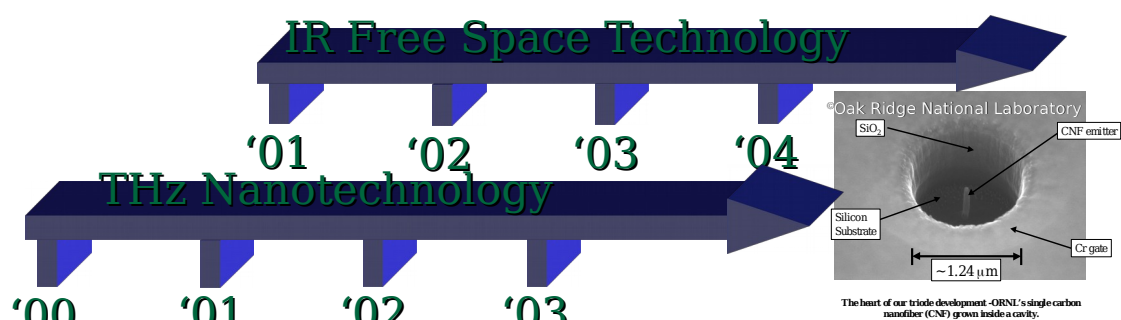
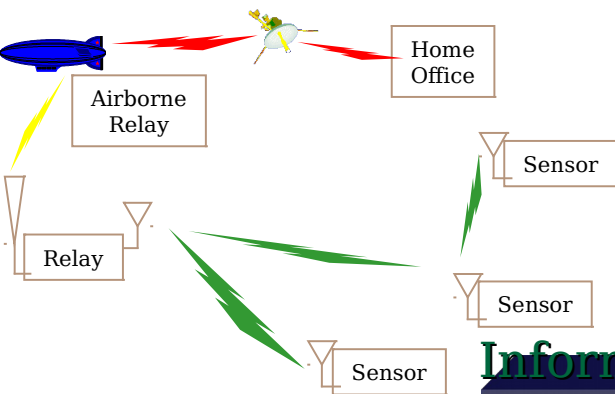
- **Self-Powered - harvesting, helium ion-based batteries**
- **Smaller Footprint, Improved Noise Immunity - SiGe ASICS**
- **Reliability - error detection/correction**
- **Embedded Intelligence - Sensor Agents**

Wireless Program at ORNL Provides

Significant Leverage

- **LDRDs - wireless microsensors, embedded wireless biosensor -**
- **Commercial Supplier - wireless MEMS -**
- **Oil Industry - robust architecture -**
- **Navy - Power management for wireless sensors NASA - launch vehicle status -**

Part of Large, Leveraged R&D Program

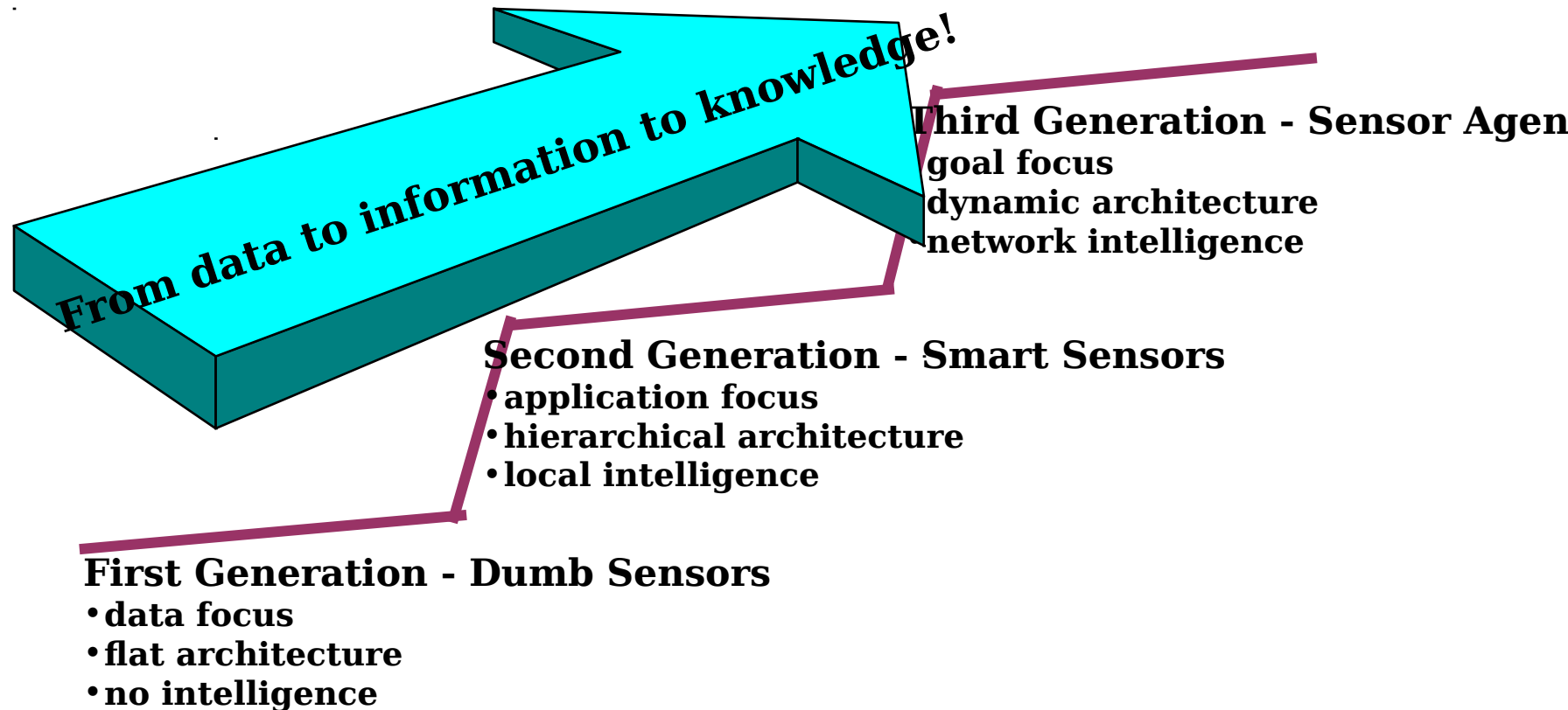


**Our Project
Highlighted
in April
2000 Issue
of Sensors
Magazine**

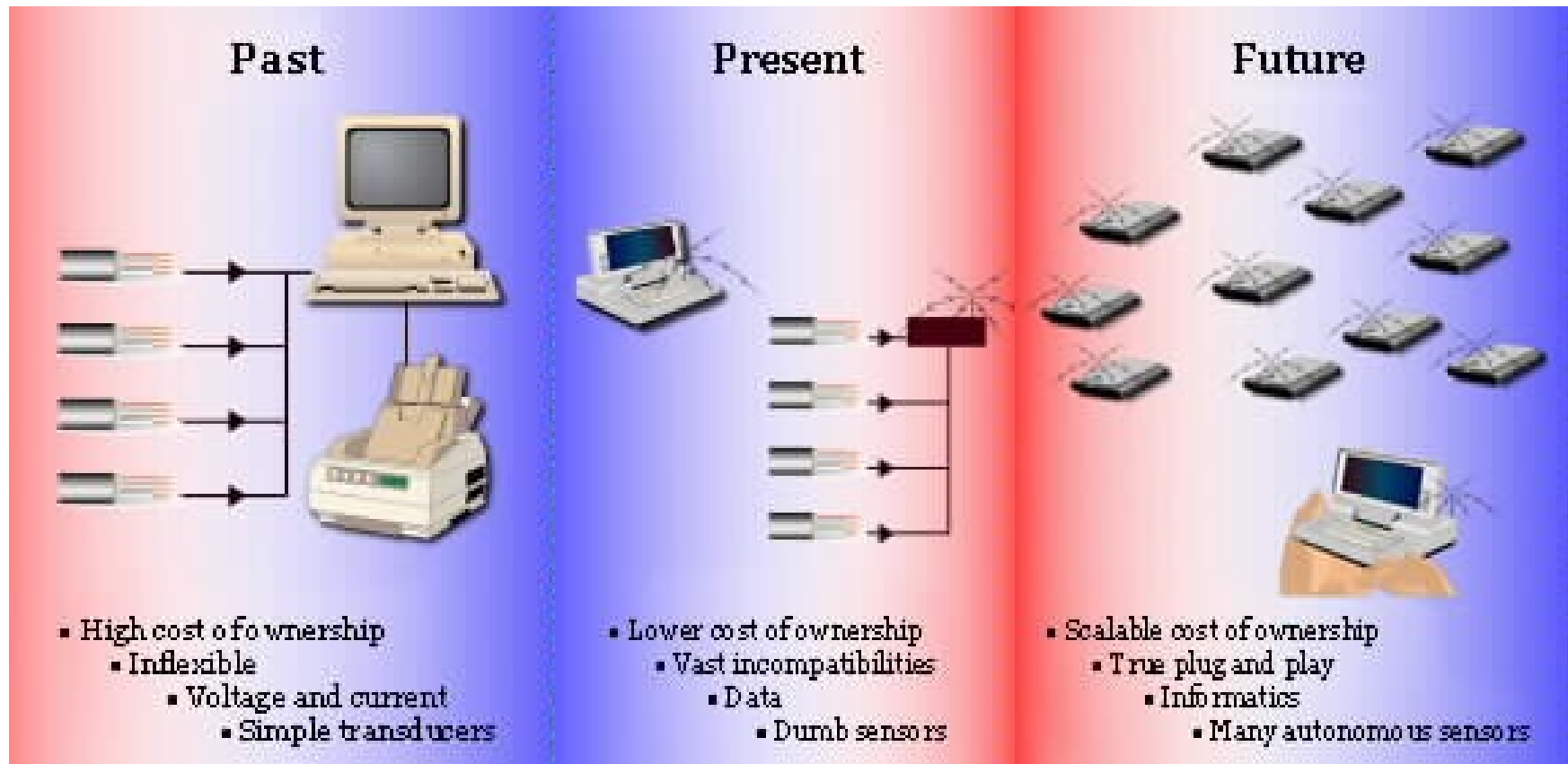
**Follow-up
Article in
April 2001
Stressed
Wireless
Sensor
Issues**

Special Section in August 2001 Issue Stressed Sensor Agents

What Is The Next Generation Sensor System?

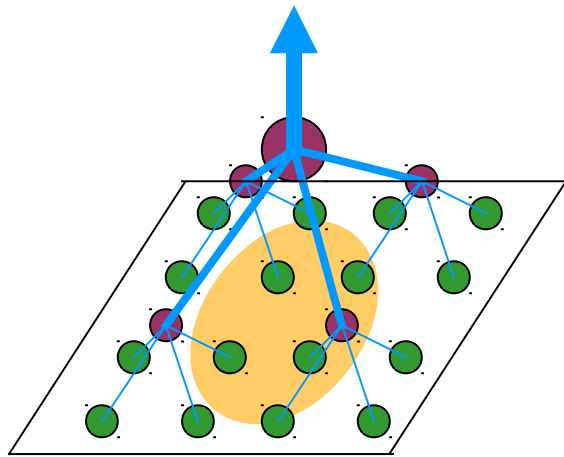


The Future: The Sensor IS the Network



Next Generation Measurement System Architecture

Present-day systems
have fixed hierarchy



Data Flow
(bigger is more)



Computing
(bigger is more)



Sensor

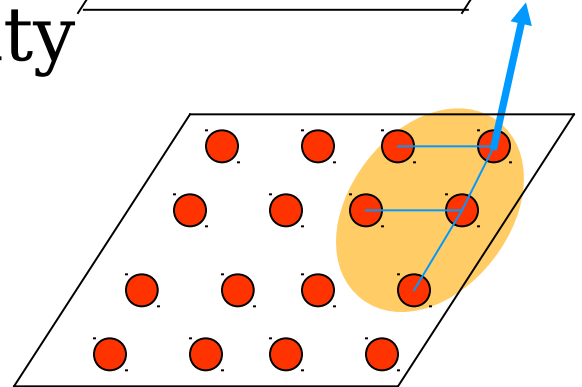
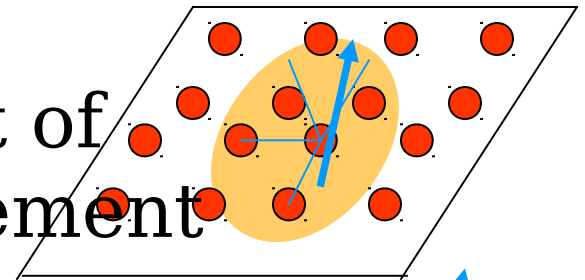


Phenomenon



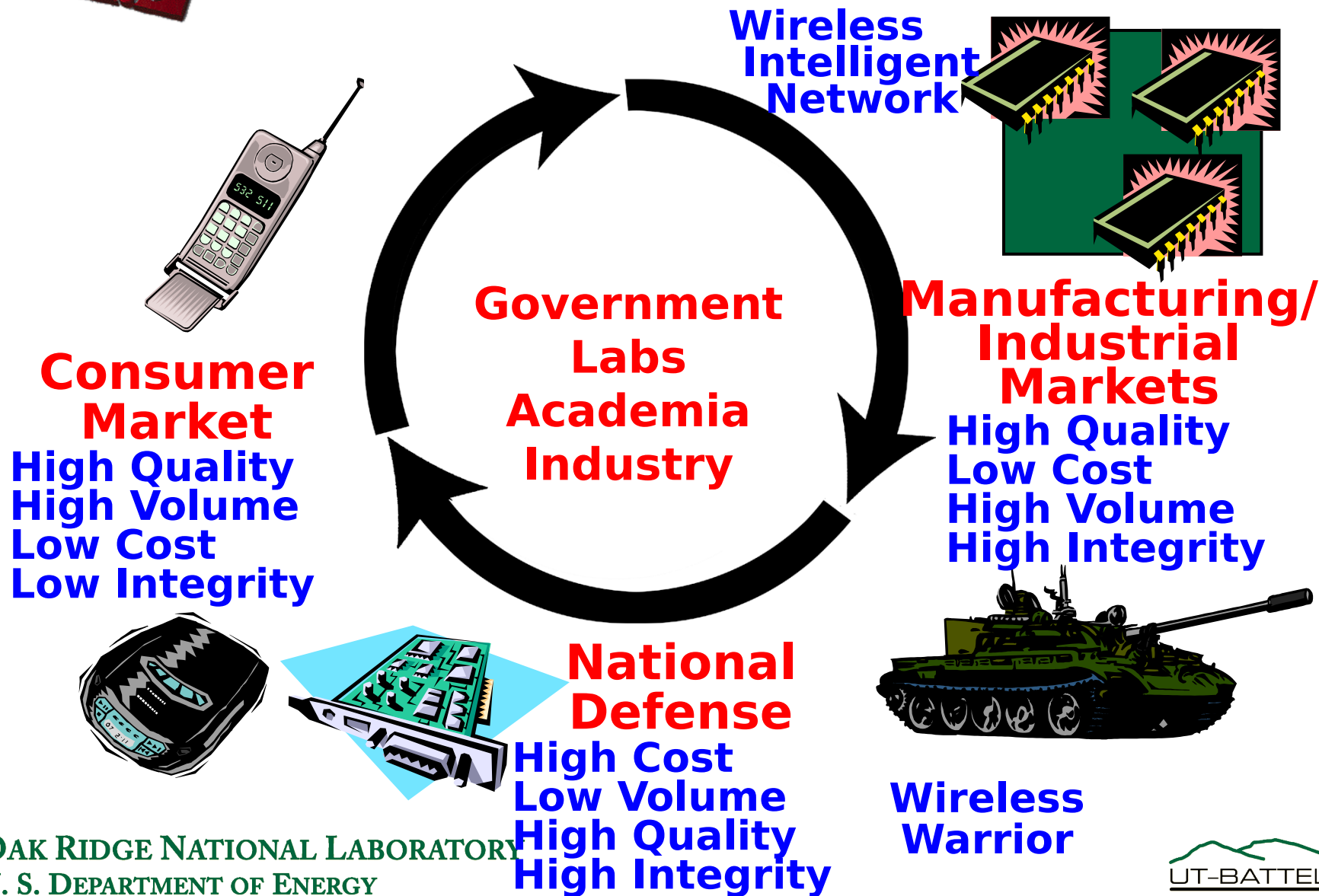
Sensor + computing

Next generation
network will self-
organize in response to
a
gradient of
measurement
density





Everybody Wins



The Government Can No Longer Afford to Be the Only Customer

- **State of the Art - Commercial vs Government use**
- **Emerging Trends - Short term, Medium Term**
- **Enablers and Disablers - Where help is needed to meet government needs**